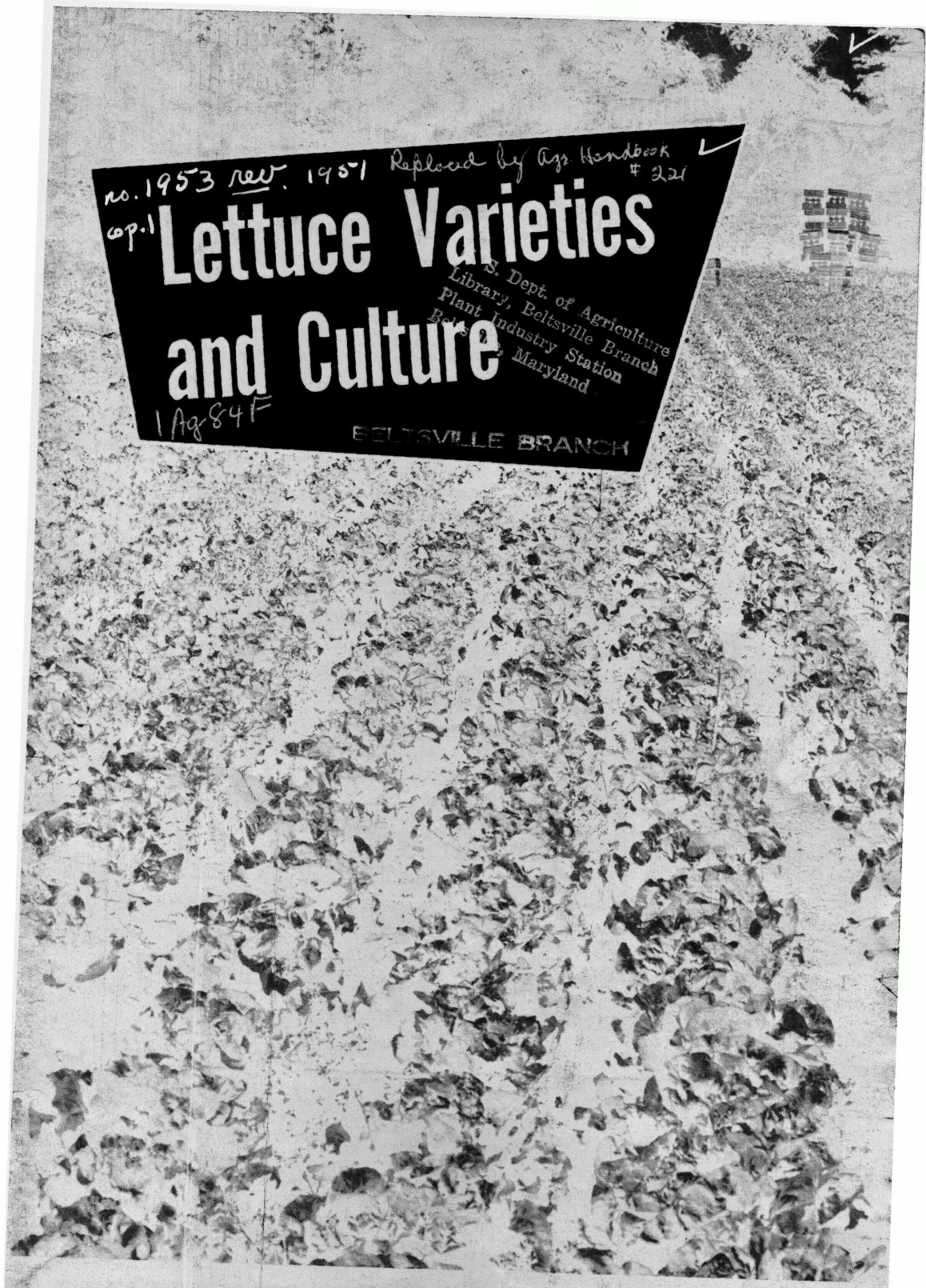
Lettuce Varieties and Culture



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LETTUCE, especially the green leaves, is an excellent source of vitamin A and supplies some vitamins B_1, B_2, and C, as well as calcium and iron. Because it is eaten raw, lettuce loses none of its vital food elements in preparation for the table.

The nonheading types of lettuce, which are relatively easy to grow where temperatures are not extremely high, can be grown satisfactorily in most home gardens. Head lettuce, however, is among the most difficult of the vegetable crops to grow to perfection and is not well adapted to home gardens in most areas because of its very exacting climate and soil requirements.

The commercial outdoor lettuce crop consists mainly of a few highly selected varieties of the crisphead type. They are being constantly improved by breeding and selection for greater uniformity, disease resistance, and adaptation to climate. Most commercial head lettuce is produced in the cool, irrigated districts of some of the Western States and certain sections in the East. Head lettuce is shipped from the West throughout the year. In the East it is grown mainly as a spring crop.

The growing of good head lettuce in the Eastern States depends on the crop's maturing before hot weather. In many localities it is necessary to start the plants in a greenhouse or protected bed in order to bring the crop to maturity during cool weather.

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LETTUCE VARIETIES AND CULTURE

By Ross C. Thompson, *senior horticulturist, Division of Vegetable Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration*

CONTENTS

IMPORTANCE OF LETTUCE CROP

LETTUCE *(Lactuca sativa* L.), the most important salad plant and one of the principal vegetable crops, is in demand at all seasons. The commercial crop has a larger annual value than any other vegetable grown for the fresh market. For the period 1938 to 1947, inclusive, it had an average annual value of $62,360,000. In 1948 it rose to $105,831,000 and in 1949 reached a peak of $119,717,000. These values do not include the enormous amount of lettuce grown in home gardens.

Lettuce owes its food value chiefly to its vitamin and mineral contents. It is an excellent source of vitamin A and a good source of vitamins B_1 and B_2, as well as of calcium and iron; it contains some vitamin C. Because it is eaten raw, it loses none of its food elements during preparation for the table. It has taste appeal and because of its low energy value is desirable in low-calorie diets.

Lettuce, a native of the Near East or western Asia, is one of the oldest vegetable crops. The time of its introduction into Europe is not known, but the records of Herodotus, Pliny, Hippocrates,

and Aristotle indicate that it was grown as a garden plant in ancient times. It was reported in China as early as the fifth century A. D. and was introduced into America from Europe by the early colonists. Sixteen varieties were listed as being grown in American gardens in 1806.

In the United States the main commercial crops of lettuce are produced in the following regions: (1) The western region, including California, Arizona, Colorado, Texas, Washington, Oregon, Idaho, and New Mexico; (2) the northeastern region, including Massachusetts, New Jersey, Pennsylvania, New York, and the other States bordering on the Great Lakes; and (3) the South Atlantic region, including Virginia, North Carolina, South Carolina, Georgia, and Florida. The western region produces approximately 80 percent of the commercial crop.

The nonheading types of lettuce, which are not difficult to grow where temperatures are not extremely high, can be grown successfully in most home gardens. The heading type, however, is among the most difficult vegetable crops to grow to perfection because it is very exacting in its climate and soil requirements and the crop may be greatly damaged by conditions that would have little serious effect on many other crops. A thorough knowledge of the requirements should be obtained before large-scale production of head lettuce is attempted.

TYPES OF LETTUCE AND THEIR ADAPTATION

The varieties of lettuce may be divided into five general classes: Crisphead; butterhead; cos, or romaine; leaf, or bunching; and stem. Although the culture of all is much the same, they differ somewhat in their adaptation to the many conditions under which lettuce is grown. The mature product of each class is distinctly different.

CRISPHEAD TYPE

At present by far the most important commercial type is the crisphead. Many varieties of this type are available and new ones are rapidly being added to the list, largely as a result of the breeding work of the United States Department of Agriculture and the State experiment stations. As these agencies continue to breed and select for disease resistance, adaptation, and quality, new and better strains will no doubt be developed and further changes in the list of important varieties may be expected.

Crisphead lettuce is distinguished by its firmness of head and crisp texture. Firmness of head is no doubt chiefly responsible for the enormous increase in the commercial importance of this type, because it makes it much better adapted for shipping than other types. The shipping qualities of crisphead lettuce, along with advances in methods of packing, transportation, and refrigeration, have made it possible to produce large quantities of lettuce in the areas best adapted by reason of climate and soil and to deliver it in good condition to consumers in distant markets. Nearly all the commercial lettuce grown in the Western States is of the crisphead varieties.

Some important varieties of the type are New York, or Wonderful (fig. 1), Imperial 44, Imperial 152, Imperial 615, Imperial 456, and Great Lakes.

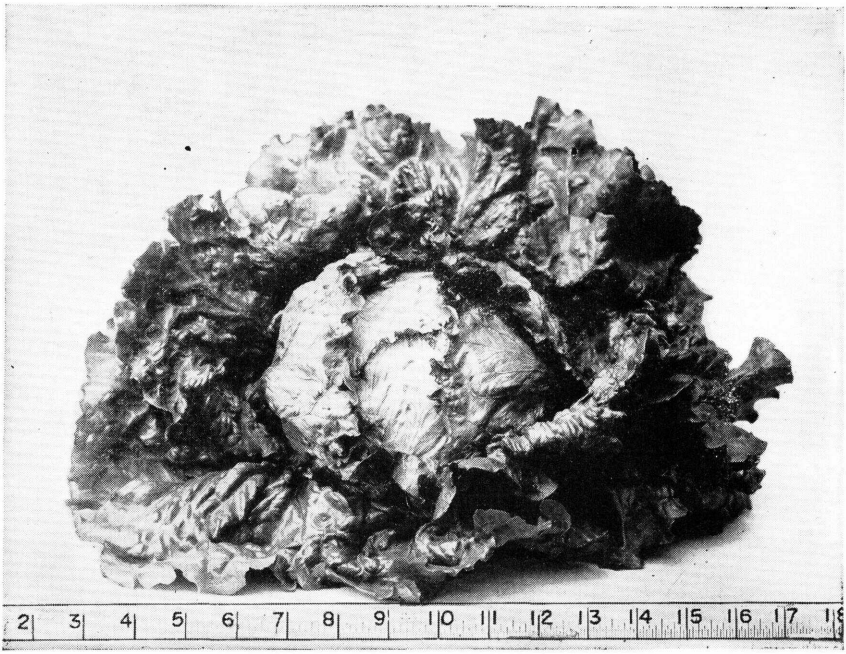

FIGURE 1.—Head of the New York, a typical crisphead variety of lettuce, also known as Los Angeles Market and Wonderful. This was the first variety to be sold under the name Western Iceberg.

BUTTERHEAD TYPE

The butterhead type of lettuce is distinguished by its soft heads, the inner leaves of which feel oily or buttery. Among the important varieties are Big Boston, White Boston (fig. 2), Salamander, May King, Wayahead, and Deacon.

Before the enormous expansion of the crisphead lettuce industry in the Pacific Coast and Mountain States much of the commercial lettuce crop was grown in the truck-growing areas near the large eastern cities and along the Great Lakes and in the Atlantic Coast States. The most common varieties were Big Boston and White Boston.

As the crisphead lettuce industry expanded in the West the demand for and the production of butterhead lettuce declined. As it is now difficult to sell this type in most markets in competition with the crisphead type, many growers near the eastern markets now grow the crisphead varieties. Some butterhead lettuce, however, is still grown as an early crop in the eastern lettuce regions because some people and some markets prefer it.

COS, OR ROMAINE, TYPE

The varieties of the cos, or romaine, group are distinguished by their elongated heads, stiff leaves, and upright habit of growth.

FIGURE 2.—Head of White Boston lettuce, a typical butterhead variety.

The best cos varieties are Paris White and Dark Green (fig. 3).

Although popular and long grown in Europe, the cos varieties have never been grown extensively in this country. They are considered by some to be the best of all types in quality. The leaves, though somewhat coarse, are sweet and of good quality and generally have less of the bitterness characteristic of some other types.

Cos lettuce is less well adapted to shipping than either the crisphead or the butterhead type; hence it is more difficult to deliver

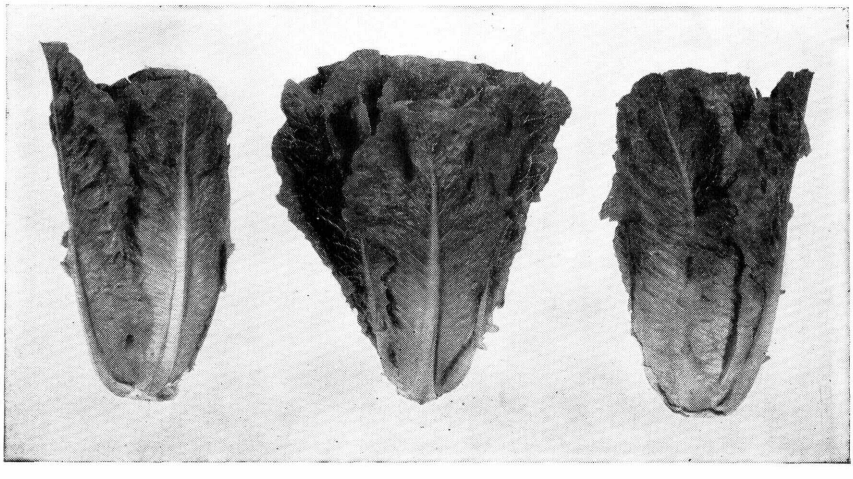

FIGURE 3.—Trimmed heads of Dark Green, a cos variety.

to the consumer in good condition. Its poor shipping qualities have no doubt limited its commercial production, but it is well adapted to the home garden.

LEAF, OR BUNCHING, TYPE

Leaf, or bunching, lettuce is distinguished by its loose, non-head-forming leaves. It is the most important type for the home garden, as it can be grown where the temperature is too high for successful production of other kinds of lettuce.

The most important leaf varieties are Black-Seeded Simpson, Early Curled Simpson, Grand Rapids, Prize Head, and Slobolt (fig. 4).

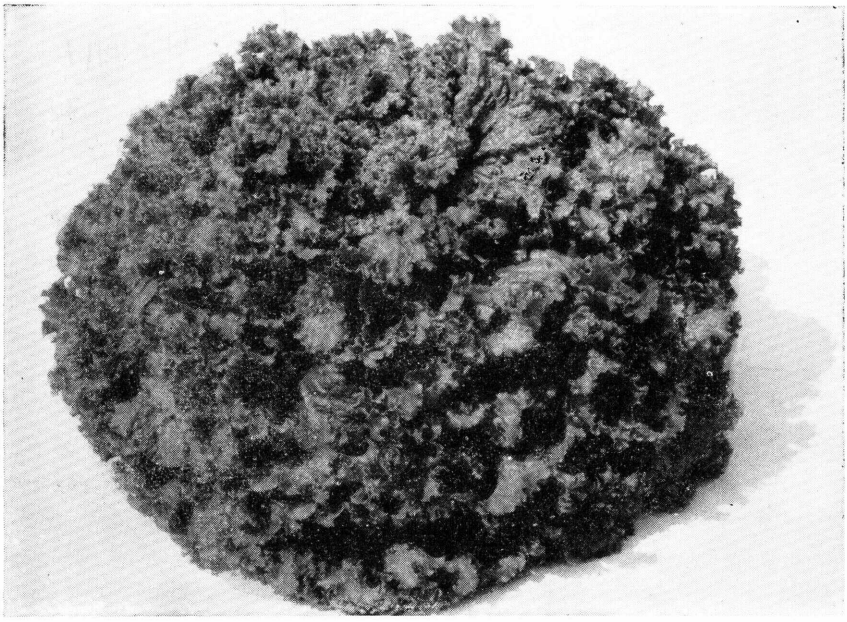

FIGURE 4.—A plant of Slobolt leaf lettuce.

Leaf lettuce is much better adapted to growing under glass than the other types. Most of the lettuce now grown in greenhouses is of different strains of the Grand Rapids variety.

STEM TYPE

Stem lettuce is distinguished by its much enlarged stem and the absence of a head (fig. 5). Although edible, the leaves are not so palatable as those of the other types, except possibly while they are very young and tender. Stem lettuce is grown principally for its large fleshy stems, which are peeled and eaten raw or cooked. There are several varieties and strains, but seed of only one, sold under the name of Celtuce, is now offered for general sale by seedsmen.

Although stem lettuce has not been grown and used widely enough in this country for its adaptation and probable future

FIGURE 5.—A plant of stem lettuce.

importance to be fully determined, it does not appear likely that this type will gain wide favor here.

DESCRIPTION OF IMPORTANT VARIETIES

The list of lettuce varieties includes more than 1,100 names, but nearly every important variety has been listed under several names. The variety Salamander, for example, has been cataloged under 50 different names. There are about 150 distinct varieties, of which some 20 or 25 are commercially important.

The commercial pack of the several strains of the variety New York and several Imperial varieties from the Western States are marketed in the East as Iceberg or Western Iceberg lettuce. It is regrettable that the term "Iceberg" has been applied to these varieties. The true Iceberg variety has been in existence for many years and is distinctly different from the varieties New York and Imperial, to which the name has been erroneously applied by shippers and produce dealers.

The following are among the most important commercial varieties of lettuce.

CRISPHEAD VARIETIES

New York.—A very large, dark-green, late, slow-bolting variety. Leaves broad, fairly heavily blistered, crumpled, thick, and coarse (fig. 1). Texture very firm, crisp; quality good. Seed whitish.

This variety was introduced into the United States in 1896 by Peter Henderson & Co. Although generally known under the name New York, it is also called Wonderful and Los Angeles Market. New York is an excellent shipping variety and was the one first shipped to the eastern markets as Iceberg or Western Iceberg. It was formerly the leading crisphead variety and the one on which the lettuce industry of the West was built. The old standard New York has been largely replaced by new disease-resistant and better adapted strains, most of which have New York as a parent.

New York No. 515.—An earlier, lighter green, and more disease-resistant strain of New York than the original. The plants tend to have an upright habit of growth in the early stages. Heads round, firm, and well-formed. Seed whitish.

New York No. 515 was developed by the Pieters-Wheeler Seed Co. from a cross between the regular New York and the true Iceberg. An improved strain, the variety has been developed and, because of its greater resistance to tipburn, has replaced other New York strains where tipburn is severe.

Imperial 44.—A medium-size, late, grayish-green, crisp lettuce. Leaves long, moderately savoyed and crumpled, margins smooth and regular. Heads well-formed, well-covered with wrapper leaves, tending to be conical in shape under some conditions. Texture firm and crisp; quality good. Seed whitish.

Imperial 44 was developed and introduced by the United States Department of Agriculture in cooperation with the New York (Cornell) Agricultural Experiment Station. Although first selected for its adaptation to eastern conditions, especially the muck lands of northern New York, it is now grown mostly in the Western States. Owing to its susceptibility to tipburn it has been largely replaced by strains of Great Lakes throughout the eastern lettuce-growing areas. Imperial 44 is a very high quality lettuce. It produces large, well-formed heads where growing conditions are not favorable for tipburn.

Imperial 152.—A large, medium-early, medium-dark-green, slow-bolting lettuce. Leaves large, broad, blistered and crumpled, and slightly curled at the margins. Heads round, firm, slightly flattened on top, partially exposed. Texture crisp; quality good. Seed whitish.

Imperial 152 was developed and introduced by the United States Department of Agriculture and the California Agricultural Experiment Station. Although one of the leading commercial varieties for early planting in California and Arizona, Imperial 152 is too susceptible to tipburn to be adapted to the eastern climate.

Imperial 456 (Cornell 456).—A medium-size, medium-green, thick-leaved, early-maturing, slow-bolting, tipburn-resistant crisphead variety. Heads small to medium and firm. Texture coarse; quality good. Seed whitish.

Imperial 456 was developed and introduced cooperatively by the United States Department of Agriculture and the New York (Cornell) Agricultural Experiment Station. Although introduced under the name Imperial 456, it is often called Cornell 456. This variety is somewhat limited in its range of adaptation. It was originally selected for its adaptation to the muck soils of northern New York, but it is being grown with some success on upland soils in New York.

The slow-bolting habit and lack of vigor of Imperial 456, attended by difficult emergence of the seed stem, presents a problem in seed production, and seed yields of this variety are generally low.

Imperial 615.—A very large, late, grayish-green lettuce. Leaves broad, only moderately savoyed and crumpled, fairly thick, and coarse. Plant has a spreading habit of growth. Heads very large, slightly flattened on top, partially exposed, surrounded by many wrapper leaves. Texture firm; quality good. Seed whitish.

Imperial 615, one of the largest of the commercial varieties, was developed and introduced by the United States Department of Agriculture and the California Agricultural Experiment Station in 1934. It is the most important variety in the Imperial Valley of California and is planted extensively in other Western States. It is primarily a cool-weather lettuce. Because of its susceptibility to tipburn and its tendency to become oversized and ribby in warm weather, it is not adapted to eastern conditions.

Imperial 847.—A large, late, dull-green lettuce. Leaves large, savoyed and crumpled, and slightly curled at the margins. Heads large, round, and partially exposed, but with abundant wrapper leaves. Texture firm, crisp; quality good. A relatively sure header and intermediate in bolting. Seed black.

Imperial 847 was developed and introduced by the United States Department of Agriculture and the California Agricultural Experiment Station in 1936. It is one of the best and most widely grown of the Imperial strains. It was formerly widely grown throughout the eastern lettuce districts, but owing to its premature bolting and tendency to tipburn this variety has been

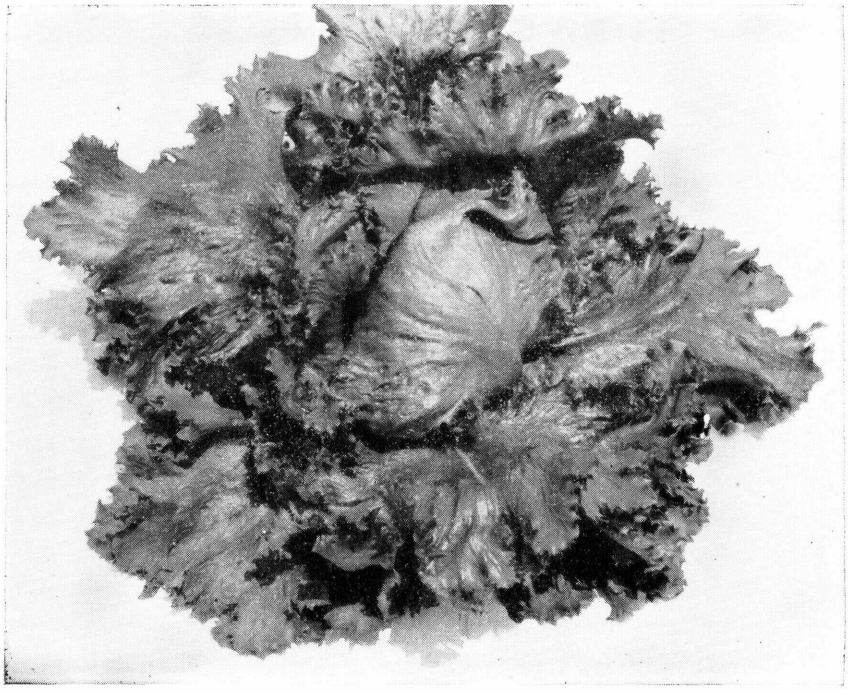

FIGURE 6.—Head of Great Lakes lettuce.

largely replaced by strains of Great Lakes. Imperial 847 is still an important variety in the central California and other Pacific coast and Rocky Mountain areas.

Great Lakes.—A very large, late, dark-green, thick-leaved, slow-bolting, tipburn-resistant variety (fig. 6). Texture firm and coarse; quality poor. Seed whitish.

Great Lakes was introduced in 1941 by the United States Department of Agriculture and the Michigan Agricultural Experiment Station. Because of its ability to produce marketable heads under adverse climate conditions Great Lakes has become one of the most widely planted varieties. It is now the most important variety in most of the eastern lettuce-growing States and is rapidly gaining favor in the West.

When first released, Great Lakes was variable and not fixed for type; consequently, numerous strains have been selected from the original stock and several are now in the seed trade. These strains vary in size, season of maturity, and resistance to tipburn. Among the best of the Great Lakes strains are Nos. 407, 428, 3238, 97145, A 36, and Premier. The slow-bolting habit and difficult emergence of the stem from the dense head make Great Lakes a poor yielder of seed.

Pennlake.—Early, medium-size, medium-green, thick-leaved, slow-bolting crisphead lettuce. Somewhat resistant to tipburn. Heads round, firm. Texture firm and crisp; quality good. Seed whitish.

Pennlake was developed and released by the Pennsylvania Agricultural Experiment Station in 1947. It is an early-maturing Great Lakes type. It is now widely planted in New Jersey, New York, and Pennsylvania, and to some extent in the New England States. Pennlake is susceptible to cold injury and has not proved well adapted in the South Atlantic States for this reason. At present its production is limited largely to the Northeastern States.

Big Boston.—A medium-large, dull-light-green lettuce, intermediate in season; shooting to seed early. Plants upright in early stages but maturing with well-formed, broad, slightly pointed heads. Leaves very broad, fairly smooth, slightly crumpled, thick but not easily broken. Head firm for a butterhead variety. Texture coarse; quality fair. Seed whitish.

Big Boston, introduced by Peter Henderson & Co. about 1870, is probably the most widely distributed variety in cultivation, listed by practically every seedsman in America and also in Europe, where it is known as Trocadero. There are numerous strains of the variety. It was formerly planted extensively for carlot production in the eastern part of the United States, but, like other butterhead varieties, it has been largely replaced by crisphead ones. It has a decided tendency to tipburn.

White Boston.—Characteristics same as those of Big Boston except that most strains (fig. 2) are lighter green and all are free of the reddish-brown pigment characteristic of Big Boston. Seed whitish.

White Boston has replaced Big Boston in many of the districts that grow butterhead varieties. Although still popular where butterhead lettuce is grown, it has been largely displaced by crisphead varieties.

May King.—An early, small, light-green lettuce tinged with reddish-brown pigment (fig. 7). Plant upright in early stages. Leaves short, broad, crumpled but smooth at edges. Head small to medium in size, compact, with creamy-yellow interior; quality excellent. Seed whitish.

May King is one of the favorite butterhead varieties for the home garden, especially in the northeastern part of the United States. It is well adapted for coldframe and early outdoor culture, but scorches easily; hence it is not adapted for late planting.

Salamander.—A medium-large, midseason, light-green, fairly rapidly bolting lettuce. Plant compact or slightly spreading. Leaves broad, much savoyed and crumpled, thin, and soft. Head globular, fairly firm, and well blanched. Texture soft; quality excellent. Seed brownish black.

Salamander is often called Black-Seeded Tennisball. It has probably been sold under more names than any other lettuce. Because it withstands hot

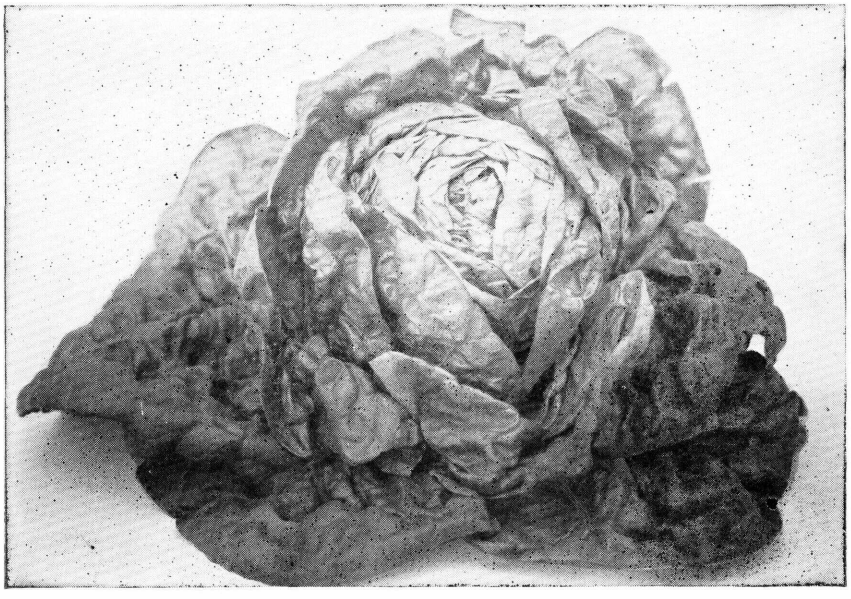

FIGURE 7.—Head of May King lettuce.

weather better than most butterhead varieties, it is a popular local-market and home-garden lettuce.

Wayahead.—A small, early, medium-dark-green variety. Plant small to medium, compact, with few outer leaves. Head small but fairly solid; quality excellent. Seed whitish.

Wayahead is a popular small butterhead lettuce well adapted for early-spring and fall culture out of doors.

COS, OR ROMAINE, VARIETIES

Paris White.—A large, late, medium-green, slow-bolting variety. Plant large, upright, self-closing. Leaves long-oval to slightly spatulate, only slightly savoyed, thick, stiff, coarse. Texture crisp and coarse; quality excellent. Seed whitish.

Paris White, also known as Trianon, is probably the most popular of the cos varieties. It is a very high-quality lettuce. Most varieties of this type are of European origin.

Dark Green.—Characteristics same as those of Paris White except for being darker green, a little shorter, and more open at the top of the head (fig. 3). A high-quality lettuce. Seed whitish.

LEAF, OR BUNCHING, VARIETIES

Black-Seeded Simpson.—A large, yellowish-green, slow-bolting leaf lettuce, early to intermediate in season. Plant large, compact, somewhat upright in habit of growth. Leaves very broad, heavily savoyed and crumpled, thick, and coarse. Texture crisp and coarse; quality fair. Seed large, blackish.

Black-Seeded Simpson, a very old variety listed first by Peter Henderson & Co., is the most widely adapted and one of the best of the leaf varieties. It is one of the best of all varieties for growing in hot weather.

Early Curled Simpson.—An early to midseason, medium-size, yellowish-green, slow-bolting lettuce. Plant spreading. Leaves short, spatulate to broad, heavily savoyed and crumpled, thick and stiff, frilled at the margins. Texture hard and coarse; quality fair. Seed large, whitish.

Grand Rapids.—An early to midseason, yellowish-green, early-bolting lettuce. Plant spreading in early stage but becoming fairly compact at maturity. Leaves long, spatulate in shape, heavily blistered, crumpled, with thick midribs, much frilled at margins. Texture coarse; quality poor. Seed black.

Grand Rapids was originated many years ago by Eugene Davis, a market gardener of Grand Rapids, Mich. It is still one of the best known and most widely grown of the leaf varieties. It is the most extensively used of all varieties for growing under glass and is well adapted for spring planting out of doors, especially in the Northern States. The much-frilled leaves of Grand Rapids make it especially desirable for garnishing.

There are several strains of Grand Rapids, each adapted to specific conditions or having resistance to certain diseases. Seed of Grand Rapids is often difficult to germinate.

Slobolt.—A relatively slow-maturing, light-green, very slow-bolting leaf variety, quite similar to Grand Rapids. The leaves are savoyed and crumpled and frilled at the margins. Texture coarse; quality fair. Seed black (fig. 4).

Slobolt was developed by the United States Department of Agriculture and released in 1944. Its chief merit is its ability to produce edible lettuce for a long period before going to seed. It is the slowest to bolt of all cultivated varieties of lettuce. Slobolt is well suited for the home garden, especially where the older varieties go to seed quickly.

STEM LETTUCE

Celtuce.—A large-leaved, thick-stemmed, dull-dark-green, slow-bolting lettuce (fig. 5). Plant large and spreading. Leaves long, slightly spatulate, with few blisters, thick, and coarse. Stems very thick. Quality of core good. Seed whitish.

Celtuce is the only variety of stem lettuce grown commercially in this country. The stems are very thick, reaching a diameter of 2 inches or more

if grown on fertile soil in cool weather. In warm weather the stems elongate rapidly and never develop the thickness attained at lower temperatures. The raw or cooked core of the stems is much liked by some people.

FACTORS INFLUENCING FIELD PRODUCTION

Although one or more of the several types of lettuce can be grown in nearly all parts of the United States, production of heading varieties on a commercial scale is very much localized because of climate limitations.

Temperature, moisture, and soil are all important in the successful production of lettuce under field conditions; however, temperature is most frequently the limiting factor. Lettuce, especially the heading varieties, requires a relatively low average temperature, particularly during the latter part of the growing period. The principal reason for failure to produce heads is that the seed stems begin to elongate, or bolt, before the heads reach maturity. This causes a separation of the leaves at the base and results in a loose or puffy head. If bolting starts early it may prevent heading altogether. The influence of temperature on the development of the seed stem is a very critical factor in the production of head lettuce where the temperature is high during a large part of the growing season.

Head lettuce could be grown successfully as a fall crop in many parts of the East, except for the fact that the temperature during the first half or more of the growing season is so high that the seed stem in most varieties begins to elongate before the weather becomes cool and favorable. Once the seed stem begins to elongate, further development cannot be prevented no matter how favorable the growing conditions may be thereafter. Much has been done through the breeding work of the United States Department of Agriculture and the State experiment stations to overcome the hazard of premature bolting by the development of new slow-bolting varieties. These withstand higher temperatures for a longer time before shooting to seed than do the old standard varieties like New York and Big Boston.

The development of the seed stem is accompanied in most cases, especially in warm weather, by an increase in the bitterness characteristics of many varieties.

Head lettuce is much more susceptible to injury from unfavorably high temperature the last few days before it reaches maturity than earlier in its development. During this period the leaves, especially those forming the outer covering of the head, become susceptible to tipburn (p. 33).

In some areas, the South Atlantic States particularly, hard, untimely freezes in the period just following the transplanting of the seedlings from the plant beds to the field frequently interfere with field production of both the heading and the cos types.

Unfavorable moisture supply frequently prevents normal growth of lettuce, particularly throughout the eastern districts. Lettuce requires a fairly abundant and constant water supply. Low soil moisture is extremely injurious to head lettuce except in the very early stages, when the rate of growth may be severely checked and the maturity of the crop delayed. Even a few days of very low soil moisture may be ruinous to a lettuce crop in the late stages

of development. Many lettuce growers in the East could greatly increase both the yields and the quality of their crops by the installation of irrigation systems. Most of the western crop is grown under irrigation, where soil moisture is largely under the control of the grower.

Although lettuce has a high soil-moisture requirement, it will not thrive under conditions of excessive soil moisture. Prolonged heavy rains, with water standing near or on the surface for even a few days, may do great damage. Excessive rainfall and low temperature often damage lettuce when grown as an early-spring crop.

As the soil-moisture content is one of the important factors in successful field production of lettuce, the Western States, where the crop is grown almost entirely under irrigation, have a decided advantage over the Eastern States, where regulation of soil moisture is largely out of the control of the grower. Even where irrigation is used in the East the grower does not have so complete control of the soil moisture as in the West, because of heavier and more frequent rains. Heavy rains after the heads begin to form may cause great loss by upsetting the growth rate of the plant, especially on fertile soil high in available nitrogen. The damage done by a sudden change in soil moisture at this time is likely to be greatest if the crop has been growing with somewhat less than optimum moisture. A sudden increase in soil moisture, with the resulting rapid growth, at any time after the heads have begun to form may interfere with the normal folding in of the leaves, thereby preventing the formation of a solid head. Any increase in the space between the bases of the leaves after they have begun to tighten over the head is likely to result in large puffy heads. Only when very favorable temperature and moisture supply prevail for several days after such a loosening of the leaves is it possible for firm heads to develop.

Soil, the third of the three factors mentioned as being especially important in the field production of lettuce, is only relatively less important than temperature and moisture. Sometimes the physical state of the soil, its lack of the proper amounts and balance of plant nutrients, or other unfavorable conditions may keep a lettuce crop from being profitable. Usually, however, soil conditions are more nearly within the grower's control than either temperature or moisture. Many of the troubles associated with the soil can be corrected by practical methods.

Lettuce is one of the most sensitive of the vegetable crops to the acid-alkaline balance of the soil. It is intolerant of acidity and, in general, the reaction of the soil should be nearly neutral. However, lettuce has a fairly high salt tolerance and is grown on alkaline soils in the western irrigated districts. In many parts of the East the soil is too acid for the maximum growth of lettuce and lime must be applied to correct the condition. Extremely acid soils should be avoided, or the reaction should be adjusted by the application of lime a year or two before planting the lettuce, so as to permit the soil reaction to come to a state of balance. Heavy applications of lime may be injurious. Under eastern conditions it is best to maintain a slightly acid reaction (pH 6.0 to 6.5); experimental evidence indicates that too heavy liming may be harmful. For best results the pH of lettuce land should not be below 6.0.

Throughout the South Atlantic States, many soils are low in magnesium. Deficiency of magnesium, as indicated by a chlorotic condition of the leaves between the veins while the area adjacent to the veins remains green, is common in many fields along the South Atlantic seaboard. It is advisable to apply only dolomitic lime high in magnesium (16 percent or more of magnesium oxide) where evidence of deficiency of this element is observed in lettuce plants. Where the pH is already high enough, it may be necessary, or at least advisable, to apply 25 to 50 pounds of magnesium sulfate to the land shortly before planting to lettuce.

ROTATIONS

Lettuce should not be grown too frequently on the same land, but some system of crop rotation should be followed. Plants of the same family are often subject to the same diseases and insect pests. Endive, chicory, dandelion, and other members of the lettuce family should not be used in a rotation with lettuce; it would tend to defeat one of the important purposes of rotation—the reduction or elimination of soil-borne agents that cause disease. Some of the most serious lettuce diseases can be controlled only by sanitary field conditions. Crop rotation is very important in areas subject to epidemics of drop, bottom rot, big vein, and other diseases that may be carried over in the soil.

Crops that are adapted to the locality and can be fitted into the general plan of farm operations should be selected for a rotation. Deep-rooted plants like alfalfa and clover are well adapted for use in a rotation with a shallow-rooted crop like lettuce. Some of the small grains and forage crops like rye, wheat, soybeans, vetch, and cowpeas may be used in a rotation with lettuce, as they are not subject to the diseases common to lettuce. Vegetable crops that are not usually attacked by the agents that cause diseases in lettuce are beets, cucumbers, melons, onions, pumpkins, radishes, spinach, sweet corn, and tomatoes.

Crop rotation is also important in maintaining soil fertility. Plants differ in their feeding capacities in that they remove the various elements from the soil in different amounts. Frequent growing of a crop on the same land may deplete the soil of certain essential materials.

SELECTION, PREPARATION, AND IMPROVEMENT OF SOILS

SOIL REQUIREMENTS

Soils vary in mineral and organic-matter content from those that are almost wholly mineral, like certain very sandy soils, to those that are highly organic, like muck. The fertility of a soil, that is, its capacity to produce a satisfactory crop of any particular plant under favorable climate conditions, depends on the presence of many chemical elements in forms available for plant growth. Some constituents of a fertile soil contribute to the plant's growth largely by improving the physical and water-holding capacity, as does humus. Some serve largely by making other elements more available to the plant. This is one of the functions of lime. Ele-

ments such as nitrogen, phosphorus, potash, magnesium, iron, and manganese help to build new plant tissues.

The foregoing statements on the complexity of soil composition point out the extreme variability that may exist among different soils in their natural fertility or capacity to support growth and show how unwise it is to make recommendations for improving the crop-producing capacity of a soil without considering specific information as to its composition and the amount and kinds of fertilizing materials previously applied.

Farmers know that fields and even different parts of the same field differ in crop-producing capacity. To obtain uniform fertility would require the application of different elements in different amounts to different parts of a single field. This is of course impractical. The differences in producing capacity are greatly magnified from one field to another and from one locality to another. To increase the crop-producing capacity of any piece of land, the grower must determine its specific requirements largely by observation. He must note the response of his crops to any fertilizing material, take into consideration the amounts of the fertilizing elements previously applied, and consider to what extent such materials may have been removed by crops or lost through leaching by rain or irrigation water. The inexperienced should follow closely the practice of the most successful growers in the locality.

Lettuce is grown successfully on a wide range of soil types, from clay loams to sandy loams and muck, but it reaches its highest quality on fertile loams that are not too light in texture and are high in organic matter. Very light soils low in organic matter are not adapted to lettuce growing. Upland soils of this kind are very unsatisfactory. Fluctuation of the moisture content is one of the principal reasons why very light mineral soils should be avoided in growing lettuce. Light soils can be used to best advantage for a lettuce crop that makes most of its growth and matures in cool weather.

Contrary to a rather general belief, lettuce does well on heavy clay. Soils of this type are difficult to work, but, when properly handled, they yield excellent crops. Well-drained muck produces good lettuce. Its high organic content gives it a high water-holding capacity and affords a more uniform moisture supply than can be attained on other kinds of soil.

Soils that have a tendency to crust on the surface may not produce a satisfactory stand of plants, especially if the surface is puddled by heavy rain after planting and before the seedlings emerge.

Lettuce is a relatively expensive crop to produce, but when properly grown it promises high returns per acre. A good crop of lettuce cannot be grown on land in a low state of fertility. Considering the extreme complexity and variability of soil in its composition and crop-producing capacity, it is obvious that only general recommendations can be given in a bulletin of this kind; it can point out only some of the essential characteristics of a highly productive lettuce soil and leave it to the grower to approach

these standards as closely as possible with the methods and materials available to him.

BUILDING ORGANIC MATTER

High organic content is one of the prime requirements of a soil for lettuce culture. Western soils are more generally lower in organic matter than the soils in the East. There is probably no better source of organic matter than well-decomposed barnyard manure, but animal manures from various sources and kinds of animals differ greatly in content of nutritional elements. Poultry, swine, and sheep manures are very high in nitrogen as compared with horse and cattle manures, rating in the order named. Manure fresh from the stalls or poultry yard is likely to be much higher in the nutritional elements, especially nitrogen, than manure that has been piled and permitted to ferment or that has been exposed to leaching by rains. The kind and previous treatment of any manure must be taken into consideration in estimating its value for increasing the productive capacity of a soil. Additional fertilizing elements from other sources will be required when manure that has been leached or permitted to ferment is used.

Fresh undecomposed manure, strawy manure, or manure containing coarse material should be applied and thoroughly incorporated with the soil long enough in advance of planting the lettuce crop to permit it to decompose. Strawy manure incorporated with the soil just before planting may damage the lettuce crop by causing a temporary shortage of nitrogen, and a bad physical condition may accompany the decomposition of the unrotted organic material. Coarse, strawy manure has a tendency to leave the soil too porous or trashy and may increase the danger of injury from a shortage of moisture in dry weather.

Where barnyard manure is not available the organic matter of the soil should be maintained by some system of green-manure cropping. Such leguminous crops as alfalfa, clover, soybeans, cowpeas, and vetch are good sources of organic matter. A green-manure crop that is well adapted to the locality should be grown. The legumes are especially desirable for lettuce production because, when properly inoculated with nitrogen-fixing bacteria, they increase the nitrogen supply in addition to building humus. The rate of decomposition of green-manure crops depends on several factors, the most important of which are the stage of maturity of the crop and the moisture and temperature of the soil. Mature woody stems require more time for decay than immature plant materials. However, the amount of lasting humus-building material increases with the age and maturity of the plant.

If rye, oats, or some other nonlegume is used as a manure crop, more nitrogen will be required in fertilizing for the lettuce crop than if a well-inoculated legume is used. An application of 200 or 300 pounds of nitrate of soda or sulfate of ammonia per acre at the time the nonlegume crop is plowed under will aid in the decomposition of the plant material and add to the nitrogen supply of the soil. The rate of decomposition of organic materials is much more rapid at high than at low temperature, and the moisture supply must be relatively high for rapid decay.

For growing lettuce most soils require the application of some of the nutritional elements in the form of commercial fertilizer, unless a very heavy application of manure high in the fertilizing elements has been used.

No recommendations as to the amount and composition of commercial fertilizer for use on every field can be given here. Each piece of land has its specific requirements that must be determined largely by experience. Commercial fertilizers may be required in the form of single elements or in combination of two or more.

Of the three elements, nitrogen, phosphorus, and potassium, usually applied in fertilizers, nitrogen is in general most likely to be needed for lettuce. This is especially true in the western irrigated districts, where many soils are naturally well supplied with phosphorus and potash but are low in nitrogen. Nitrogen can be applied in either the inorganic or the organic form. The commonest forms of inorganic nitrogen are nitrate of soda, sulfate of ammonia, and ammonium nitrate. Where the soil reaction is near or above neutral, as in many parts of the West, sulfate of ammonia can be used to good advantage. In many parts of the East the soil reaction is on the acid side, and sulfate of ammonia should be used sparingly unless lime is added to maintain the proper soil reaction.

Nitrogen in the organic form may be obtained from fish scrap, dried blood, cottonseed meal, tankage, and related materials. These substances must undergo decomposition in the soil before their nitrogen becomes available to the plant. In such form the nitrogen becomes available slowly and does not cause the excessively rapid growth that may result from a heavy application of inorganic nitrogen when conditions are optimum for growth. When the temperature is low, nitrogen becomes available from organic materials in the soil at a very slow rate or not at all; therefore in the cool seasons it is best to apply part or all of the nitrogen in the inorganic form.

In some of the large producing centers of Arizona and California nitrogen in the form of anhydrous ammonia is applied to the lettuce crop through irrigation water. This requires very accurate measurements of the rate of flow of the water and of the ammonia gas. This method of applying nitrogen is adaptable only to irrigated sections where the measurement and flow of water can be well controlled. The application is made under the supervision of employees of the company supplying the compressed gas.

Fertilizer experiments indicate that in many areas lettuce responds favorably to fairly high applications of phosphorus. Probably the best source of phosphorus is superphosphate. Although bonemeal is a good source of phosphorus, it is in a form not immediately available to the plant and should not be used where immediate results are desired. Raw ground phosphate rock is generally unsuitable as a source of phosphate for lettuce because of its slow rate of availability. There is some evidence that very large amounts of available phosphorus tend to encourage premature seed-stem development, especially where the nitrogen is low, suggesting that very large amounts of available phosphate should be avoided where the crop is to mature during fairly warm weather.

Experiments indicate that lettuce does not require large amounts of potassium and may even be injured by too much. Although potassium is essential for growth of the lettuce plant, large amounts should not be applied unless local experience indicates a need for it.

Lettuce land is usually fertilized with nitrogen, phosphorus, and potassium in the proportions and amounts found by experience to be best for local conditions. A good standard formula for a complete fertilizer is 5 percent nitrogen, 8 percent phosphorus, and 5 percent potash. In using mixed fertilizers the grower should consider the sources and availability of the elements, especially the nitrogen. The composition should be varied as local conditions require. Frequently as much as a ton per acre is applied where the soil is known to be low in fertilizing elements. When such large amounts are used the fertilizer should be applied and thoroughly incorporated with the soil well in advance of planting time; otherwise, injury to the young plants may result. In cool weather much of the nitrogen should be applied in the immediately available inorganic form. Lettuce is generally side-dressed with 100 pounds or more of nitrate of soda or sulfate of ammonia after the plants have been blocked and thinned or after the crop has become well established when it is grown from transplanted plants. The application of nitrogen as a side dressing late in the development of the plant may cause too vigorous growth, resulting in large loose heads or an undesirable ribbiness.

In some lettuce regions, the South Atlantic one in particular, lettuce sometimes fails to make a satisfactory crop because the soil is deficient in certain elements like magnesium, copper, and boron. The symptoms in the lettuce plant that indicate such deficiencies are not easy for the average grower to recognize, and methods of determining the elements needed are complicated. As the deficiencies are often somewhat local in distribution and the methods of determination are complicated, it is generally necessary for the grower to depend on State or local crop or soil specialists for assistance in determining the deficient elements and the amounts required.

PREPARATION OF SOIL

Good drainage is essential in any soil to be used for the production of lettuce. If the land does not already have good drainage the provision of a drainage system is the first operation. Drainage may be accomplished by either an open trench or underground tile, the system used being determined by local condition.

The preparation of the soil for planting and growing lettuce is much the same as for growing other vegetables. Thorough preparation is essential and will do much to assure a good stand of plants and reduce the labor needed after the crop is planted. The operations required consist of plowing, disking or harrowing, leveling or floating, and ridging or bedding where the crop is to be grown on beds or ridges.

The implements and the methods of preparing the soil vary in different localities. Those employed by successful growers in the locality are the best guides.

Soil for lettuce should be plowed deep wherever practicable. Organic matter needs to be incorporated to a depth of 8 inches or more. Land for lettuce growing, especially the heavy soils, should never be plowed when wet. Lettuce seed is small and requires a finely prepared soil to assure germination. Land plowed when wet can never be put into the best condition as a seedbed for lettuce, and the bad physical condition resulting from plowing soil while too wet may cause trouble throughout the season.

Where a cover crop, sod, or heavy application of manure is to be plowed under, plowing should be done well in advance of the planting season to permit thorough decomposition of the organic materials.

In the Northern States plowing is often done in the fall, and the land is left rough during the winter if it is not subject to erosion. Fall plowing is especially desirable for heavy land that is slow to dry in the spring or has a tendency to become cloddy if worked while wet. The action of freezing and thawing on plowed land during winter leaves it in a mellow condition, and a fine seedbed can then be obtained in early spring by disking and dragging or by working with other suitable implements.

The mellowing of the soil through exposure to frost and other benefits derived from fall plowing in the North are not obtained farther south; therefore, most of the land is spring-plowed.

Whether the land has been fall- or spring-plowed, the surface soil to a depth of several inches should be thoroughly worked with a disk, harrow, or other implement until it is in a good condition for a seedbed. The implements required to put the surface in good condition depend on the texture and condition of the soil. Implements having cutting edges, such as disks and Meeker harrows, usually leave the surface in better condition for the operation of seeders than a noncutting implement such as a spike-tooth harrow. A spike-tooth harrow or similar implement has a tendency to drag clods, stones, and unrotted organic matter to the surface, and these may interfere with the planting shoe of the seeder and prevent proper covering of the seed. The final operation in preparing the seedbed should be done with an implement that will leave the surface as free of clods and trashy organic materials as possible.

In the irrigated sections of the West leveling is an important operation in the preparation of land, in order to assure the proper flow of water in the furrows. However, leveling to the extent of moving soil to a depth of more than a few inches is undesirable in most parts of the East because it leaves unproductive spots where the surface soil has been removed. Such spots may require fertilization and heavy applications of organic matter for several years before they are again productive.

Where the lettuce crop is to be grown on ridges or beds these should be thrown up and the top leveled with a light drag or roller before planting.

IMPORTANCE OF GOOD SEED

Very little lettuce seed is imported. Until recently California produced nearly all the lettuce-seed crop, but at present a good deal is being grown in Arizona and Idaho.

Lettuce seed can be kept viable for a long time if stored where it is cool and dry. It rapidly loses its ability to germinate if kept under warm, moist conditions. The percentage of germination of lettuce seed generally declines rapidly after 2 years in warm, humid places; low moisture content is essential if the viability of lettuce seed is to be maintained. Old lettuce seed should not be used for planting without first being tested for germination.

Seed of most varieties of lettuce germinates poorly if planted soon after harvesting, especially if the soil temperature is above 70° F. Some lettuce seed requires a few months of afterripening before it can be germinated readily under normal conditions. At temperatures above 70° germination can be greatly increased by immersing the seeds before they are planted in a one-half of 1 percent solution of thiourea in a shallow vessel for 8 to 12 hours. The effectiveness of the treatment declines rapidly as the soaking period is decreased below 8 hours. More than 12 hours in the solution may result in the loss of some seed through germination if the temperature is near the optimum (60° to 65°). Only enough solution to cover the seed should be used. The temperature during the treatment should be between 60° and 70°. Treated seed should be washed in tap water, spread out thinly, and thoroughly dried. The germination of dormant lettuce seed can be greatly increased, and nearly all lettuce seed can be germinated at a higher temperature, after the thiourea treatment. The resulting stimulation persists for some time.

Because of the uncertainty of the germination of lettuce seed as a result of dormancy or age, it is advisable to test its germination before planting, especially when large acreages and heavy expenses are involved.

COATED SEED

In recent years research has been conducted on coating various kinds of seeds to produce pellets of uniform size that can be planted with greater precision by mechanical seeders than is possible with seeds of irregular shapes and variable sizes. Numerous materials have been tested as coating agents. Various fungicidal, insecticidal, and nutritional compounds have been added to the coating materials in an effort to help control seedling disease and insect pests and to supply nutrients to the young plants. Much reseach is yet required to determine the best materials for use in the coating and to determine what, if any, value can be derived from nutritional, fungicidal, and other agents added to the coating.

However, enough has been done to demonstrate that coating is practicable and profitable on some kinds of seed. Lettuce is one of the vegetable seeds that has proved to be adapted for coating when the seed is correctly coated and properly planted.

Coating is somewhat expensive, but the cost may be saved in the reduction of seed required and of labor costs for blocking and thinning. Coating cannot yet be recommended for use under all conditions, but coated lettuce seed is being used successfully in some areas. Dormancy in lettuce seed may be increased by coating, especially when germination is at relatively high temperature.

One of the important causes of failure in using coated seed is too-deep planting. Coated seed should be planted approximately

the same depth as uncoated seed. Owing to its large size, however, many growers tend to plant much deeper. Poor emergence is the result.

Numerous new mechanical seeders adapted for planting coated seed are now available.

SEEDING IN PLACE

Many planting systems have been used with success in the various lettuce-producing districts of the country, but not all are equally well adapted to any particular locality. It is best to follow a planting system that has been proved by years of experience to be adapted to local conditions.

Nearly all the lettuce produced in the West and much of that in the East is grown from seed planted directly in the field with mechanical seeders. Usually about 2 pounds of seed is used per acre. If the seed is good and soil conditions are favorable for germination, a satisfactory stand of plants may be obtained with the use of as little as a pound per acre. The lighter rate of planting saves labor in blocking and thinning. However, if there is reason to believe that the seed does not have a high percentage of germination or if soil conditions are not favorable for germination, a heavier rate of seeding is necessary to assure a satisfactory stand.

Systems of planting vary from single- to six-row beds. Most of the commercial crop is now grown on raised two-row beds (fig. 8). Wide beds of four to six rows (fig. 9) were formerly used exten-

FIGURE 8.—Double-row planting system on slightly raised beds.

FIGURE 9.—Lettuce planted on 6-foot beds.

sively in some of the Eastern States for growing the Boston type of butterhead lettuce and are still in limited use. With the shift from the Boston to the New York, or crisphead, type, the system of planting throughout most of the Eastern States has changed to either the single- or the two-row bed. The single-row system of planting varies among the different districts. In some, the single rows are planted on ridges of varying heights; in others, flat culture in single rows is the practice. Ridging is desirable where heavy rains fall in the growing season and where the soil is of such a character that it does not dry quickly under the plants after rains. Some of the loss due to decay of the lower leaves may be avoided by growing the crop on narrow ridges. Ridging is not desirable on well-drained land or on light soils; there it may make the crop suffer more during periods of limited moisture supply than it would under flat culture.

The two-row bed is the most widely used system throughout the large growing districts of the West. Other systems are used, but they are not generally considered as satisfactory. The height of the bed is determined by local conditions of soil type, drainage, and alkali content of the soil.

In planting lettuce seed directly in the field with mechanical seeders it is important that the machine be adjusted to drop the seed regularly, accurately, and at the proper depth so that it will

be thoroughly covered. Lettuce seed should be planted as shallow as possible and yet be completely covered. The depth of planting is governed by the texture of the soil and its water-holding capacity. The seed may be covered deeper in light than in heavy soil. Seed should be planted a little deeper in soil that has a tendency to dry rapidly at the surface than in soil in which adequate moisture for germination can be assured. Only under exceptional conditions should lettuce seed be covered to a depth of more than one-half inch. If sufficient moisture for germination can be assured, a depth of one-eighth of an inch is enough.

Planting distances both between rows and between plants in the row differ, depending on the varieties grown and the system of cultivation and irrigation used. As a rule, the distance between rows in the single-row system should be not less than 18 inches. Varieties that produce small heads, as most of those of the butterhead type, can be grown in rows closer together than the large crisphead varieties like New York and the Imperials. If small-headed varieties are grown and all the work is to be done by hand, the rows may be as close as 12 to 15 inches. However, crowding either between rows or within the row is undesirable. The chances for loss from diseases are much greater where too-close planting causes poor ventilation around the plants. If the crop is to be cultivated by tractor-drawn cultivators the distance between rows should be not less than 2 feet.

In the western irrigated sections, where the crop is grown by the two-row-bed system, the standard distances are 12 inches between rows on 22-inch beds with 18 inches between beds, or a total of 40 inches from center to center of the beds. The top of the bed is 6 inches above furrow level.

Where the wide-bed system is still used, it is general practice to plant six rows on a 6- or 7-foot bed with a 12- to 15-inch space between beds.

Where the crop is grown under irrigation by the furrow method it is desirable to irrigate the land in advance so as to allow the soil to settle before planting the seed. In the nonirrigated districts it is preferable to plant after a rain rather than just before. In soils that tend to puddle when wet, germination may be adversely affected by the crust that forms on the surface after a rain.

Successful head-lettuce production depends on bringing the crop to maturity at a time when temperatures are favorable. In eastern United States the spring crop reaches maturity at a time when the temperature is becoming unfavorably high, and late-planted fields often fail to head but shoot to seed prematurely. Hot weather at maturity increases the loss from tipburn and slime (soft rots).

Varieties of head lettuce differ in their adaptation, especially to temperature. Such varieties as Imperial 17 and Imperial 615 have a tendency to become oversize and to form soft, ribby heads if grown during warm weather. These varieties are best adapted for growing during the cooler months, since their naturally large size gives a satisfactory commercial head when many other varieties tend to produce undersize heads. Some varieties like Imperial 847 have a wide range of adaptation and are grown over a wider area and during a greater part of the year. There are also great varietal differences in susceptibility to disease.

In the large commercial-growing districts of California and Arizona the differences in varietal response to weather conditions have led to a well-established schedule of planting dates for the different varieties. That is, the different varieties are planted on such dates that they will develop during the seasonal conditions to which they are best adapted. A schedule of planting dates used in these districts is given in table 1.

The lack of adapted varieties and the limited growing season have prevented the establishment of such a well-organized planting schedule for the eastern lettuce districts. As better adapted varieties are developed and introduced, a similar planting schedule may be developed for the Eastern States.

TABLE 1.—*Planting dates and periods to maturity for the important lettuce varieties in the commercial-production districts of California and Arizona*

District and variety	Planting Dates	Period to maturity
		Days
Imperial Valley, Calif.:		
Great Lakes	September 15–25	85–95
Imperial 152	do	85–95
Imperial 615	September 25–November 1	100–105
Imperial 17	October 1–10	115–120
Salinas-Watsonville, Calif.:		
Imperial 615	November 1–January 21	100–145
Great Lakes	February 1–June 30	90–105
Imperial 847	April 1–June 30	65–85
Imperial 44	July 1–August 1	65–85
Imperial D	August 1–20	90–100
Yuma, Ariz.:		
Great Lakes	September 1–15	85–95
Imperial 44	September 10–25	85–95
Imperial 847	September 15–30	85–95
Imperial 615	September 20–November 15	100–105
Imperial 101	October 1–20	100–105
Salt River Valley, Ariz.:		
Imperial 44	August 27–September 10	80–85
Imperial 152	September 20–November 10	95–120
Imperial 615	September 8–15	90–95
Great Lakes	August 20–September 1	80–85
	November 10–January 10	90–120

GROWING PLANTS FOR TRANSPLANTING

In order to reduce the danger of crop failure due to unfavorably high temperature at heading time a large part of the commercial head-lettuce crop in the Eastern States is started early in protected beds and transplanted to the fields. This method of culture is practiced in the lettuce-growing districts of Florida, South Carolina, North Carolina, Virginia, New Jersey, and to a lesser extent in other parts of the East wherever the last killing frost in the spring is soon followed by temperatures too high for lettuce. By having bed-grown plants of good size ready for transplanting in the field as soon as danger from killing frost is past, it is possible

to mature the crop before temperatures become too high. In certain localities some planting of seed in the field is also done as soon as soil and weather conditions permit the working of the soil and the operation of mechanical seeders. In some seasons the field-seeded plantings mature a satisfactory crop before the hot weather comes, but in the average season they cannot be depended upon in the areas mentioned.

With some of the recently introduced varieties of head lettuce a satisfactory early crop can be produced in many of the Eastern States if hotbeds or coldframes are used for starting the plants.

In the South Atlantic States most of the plants for transplanting are grown in beds in much the same manner as tobacco plants in the tobacco-growing districts of the South. The beds receive very little protection other than a covering of thin muslin. They are frequently protected from prevailing winds by selecting a location on the sunny side of a woods or thicket. A bed of this kind 100 by 10 feet should provide enough plants to set an acre or more.

Farther north, in New Jersey, for example, lettuce seedlings for field planting are grown in sash-covered coldframes. A standard sash 3 by 6 feet is in general use. A 50-sash bed should provide plants to set an acre or more.

The soil to be used for growing lettuce seedlings for transplanting should be well fertilized. About 4 pounds of a 5–8–5, a 5–8–7, or a complete commercial fertilizer of similar composition should be applied for each 100 square feet of bed and should be thoroughly incorporated with the soil some time before planting.

A quarter of a pound of good seed should produce enough seedlings to set an acre where the plants are grown in well-prepared beds and are properly cared for. The seed should be planted thinly to assure large sturdy plants. Crowding in the beds increases the danger from loss through damping-off and other diseases; furthermore, plants that have been crowded in the beds are greatly inferior to those that have had sufficient space to develop properly. The harmful effects of crowding become worse if it is necessary to hold the plants in the beds beyond the normal transplanting date because of unfavorable soil or weather conditions that delay transplanting to the field.

Great care must be exercised in watering and ventilating the plant beds to prevent loss from damping-off. Where past experience indicates that such loss may be serious, lettuce seed should be treated before planting (p. 32).

Where damping-off in the seedbeds has caused serious loss of plants it is advisable to change the soil, to locate the beds on new soil on which no lettuce has been grown for several years, or to sterilize the beds with chloropicrin or formaldehyde (p. 32).

In most of the districts where lettuce is produced from bed-grown plants it is necessary to transplant the seedlings to the field while temperatures are still relatively low. Temperatures often drop below freezing after the plants have been set in the field. Soil temperatures are frequently so low for some time after setting that the transplanted seedlings fail to obtain sufficient nitrogen for satisfactory growth. The plants often become yellowish-green from lack of nitrogen and may be badly stunted before the soil becomes warm enough for the nitrogen to become available. When

lettuce seedlings are to be moved from the plant beds to the field before the soil temperatures in the field are high enough for normal growth, the grower can do much to assist the plants through this period by applying available nitrogen about a week before removing them from the beds. Nitrate of soda alone or nitrate of soda and sulfate of ammonia in equal proportions may be applied at the rate of about one-half pound per 100 square feet of bed. If weather conditions should make it necessary to hold the plants in the bed for several days after applying the nitrogen, they may become too succulent and suffer from crowding. For this reason only such portion of the beds should be treated at one time as the grower has reasonable assurance can be transplanted to the field within a week.

BLOCKING AND THINNING

Thinning is the most laborious and expensive operation in the production of lettuce. Lettuce seeded in place, whether by seeders or by hand, requires blocking and thinning. Blocking with a hoe or a blocking machine removes from the row all the plants except small clusters at regular intervals of 10 to 16 inches. This is usually done 10 days to 2 weeks after planting. A few days later all but one of the plants are removed from each of the clusters left in the blocking operation. This is largely hand work. Neither blocking nor thinning should be delayed until the plants suffer from crowding. Frequently the sturdier plants removed in blocking are saved and set in parts of the field where the stand is poor or in other fields. In the large producing sections of the West most of the blocking and thinning is done under contract on an acre basis.

The distance between plants in the row should be determined largely by the size of the plant produced, the particular variety, and the fertility of the soil. Small varieties should be thinned to about 10 inches between plants; large varieties like New York should be left from 12 to 16 inches apart in the row. The spacing should be wider on very fertile land.

It is very important in thinning that only one plant be left in a place; where two or more are left by careless thinners, good commercial heads will not develop. Care should be exercised to avoid moving too much soil away from the plants in the blocking and thinning operations. It is often necessary to replace the soil around the plants after completion of the thinning operations. Carelessness and rough handling of the plants in doing this work may severely check development and delay maturity.

CULTIVATION

Cultivation of lettuce is done primarily to destroy weeds, but in the irrigated areas it is also important in preventing the formation of a gumbo crust in the bottom of the irrigation furrow. In non-irrigated areas thorough cultivation of the surface should follow every heavy rain, to prevent the formation of a surface crust. All cultivation of lettuce should be shallow, as the plant has a shallow root system and is a poor forager. Deep tillage may destroy many of the feeding rootlets and check the plant's development. Cultiva-

tion of any kind late in the season should be very carefully done to avoid serious injury to the crop.

Careful root pruning by cultivating equipment may be used to advantage in checking too rapid a growth rate caused by abundant moisture and favorable temperature where the soil fertility is high. This practice should be employed only by experienced growers and then only when there is reasonable certainty that the crop will be lost through overdevelopment if the growth rate is not checked.

The rows may be planted close together if cultivation is to be done with hand and wheel hoes. Small garden tractors are now in general use in the planting and cultivation of lettuce. If weeding and cultivating are to be done with tractor-drawn implements the rows should be at least 2 feet apart. Some hand hoeing is always necessary in destroying weeds close to the plants. The lettuce field should be as free of weeds as possible by the time the heads have begun to form so that a minimum of cultivation will be required during the heading period.

Cultivating and weeding implements that are best adapted to the system of planting followed in the locality should be used.

The number of cultivations required to grow a crop of lettuce varies with the character of the soil, with the weather, and, most important of all, with the amount and kinds of weed seed in the soil and the thoroughness with which weeds are destroyed at each cultivation. Two or three cultivations and one or two hand hoeings are enough under average conditions. To be most effective in destroying weeds, cultivation should be done while the weeds are still very small, the soil in good condition for working, and the sun bright. Many weeds may not be killed and may take root again if the soil is wet or if cultivation is followed immediately by a rain. It may not always be possible to arrange or control conditions so that cultivation can be done at the most effective time, but an effort should be made to take advantage of favorable weather conditions.

The amount of work and expense required to destroy large weeds may be many times that required to control them while they are small. Efficient weed control depends upon destroying the weeds while they are small.

IRRIGATION

Lettuce requires constant and fairly high soil moisture from planting to harvest. Wide fluctuation in soil moisture is undesirable at any time and may cause great damage to the crop in the late stages of development. The soil should be wet enough for only a short time after a rain or irrigation to form a ball when squeezed in the hand, but the moisture content of the soil should never go so low that more than the surface becomes dry.

Where irrigation water is applied from a sprinkling system during warm weather it is best to apply the water in the early morning, while the plants are cool and before they reach the wilting point. Great loss from tipburn and slime (soft rots) may result from careless irrigation of nearly mature lettuce by a sprinkler system during the warmest hours of the day. Rains during hot weather may likewise cause damage to the leaves.

In districts having rainfall during growth of a lettuce crop, the time and amount of irrigation should be carefully studied with relation to weather forecasts and amount of the soil moisture. The most expert growers keep a careful watch on both the weather and their lettuce crop, applying only enough water to carry the plants through until it rains. During continued dry weather irrigations usually are needed about once a week.

Lettuce grown in the eastern or humid regions requires from 5 to 8 inches of rainfall or its equivalent in irrigation to produce a spring crop, the amount depending somewhat on the character of the soil, the percentage of cloudy weather, and the prevalence of winds. The ordinary overhead, or spray, system will distribute approximately 60 gallons of water per minute over an acre, thus requiring about a 4-hour watering to apply one-half inch of water over the entire surface, or sufficient to fairly saturate the soil.

In the western lettuce-growing districts almost the entire crop is grown under irrigation. The rainfall in most of these districts is very low; consequently the soil moisture is largely within the control of the grower. Under such conditions it is essential that the grower know the moisture requirements of the lettuce plant and control the irrigation accordingly. Although practices in the West vary with the locality and character of the soil, most of the irrigation is by the open-furrow method. Considerable experience is required to use this system successfully. Skill in the control of the flow of water and knowledge of the amount and time to apply water are learned only through experience. There are two periods in the development of lettuce when even slightly excessive amounts of water are likely to be injurious to the crop. The first is the early stage, when too much water in the soil may cause the development of a shallow and limited root system. The second critical period is that just preceding maturity—a too high soil-moisture content at this time may cause a too rapid rate of growth, with soft or puffy heads resulting.

In the East, where there are few irrigation systems, the lettuce crop frequently suffers from drought. Where suitable water for irrigation is available, there is little doubt that the installation of an appropriate irrigation system could be made a profitable investment in many lettuce districts. This is becoming more often true with the development and introduction of new varieties that can be grown in the East.

HARVESTING, HANDLING, AND SHIPPING

HEAD LETTUCE

Head lettuce should not be harvested until mature unless market and weather conditions justify premature cutting. During a period of very warm weather a few days' delay in cutting the crop may mean much loss from bolting and from tipburn and other diseases. The marketing of immature, low-grade lettuce reduces the market price for the high-grade produce. When mature and ready to harvest the heads are solid and their tops are light yellowish.

In harvesting head lettuce the plant should be cut at or slightly below the soil surface, leaving as many of the wrapper leaves

uninjured as possible. The soiled and partially spoiled leaves on the base of the head should be removed in trimming for packing. Head lettuce intended for distant shipment should not be cut immediately after a heavy rain or an irrigation or in the very early morning, because the plants may be gorged with water and the outer, or wrapper, leaves are then easily broken or destroyed in handling. Head lettuce to be shipped to distant markets should retain as many sound wrapper leaves as possible, to protect the heads in transit. If it is necessary to harvest head lettuce when the leaves are very brittle from rapid growth and high water content, the heads should be very carefully cut and turned butt up for a short time to permit the outer leaves to wilt slightly, after which the heads can be handled with less danger of breaking or destroying the wrapper leaves. Excessive wilting should be avoided.

Head lettuce for distant shipping is generally trimmed and packed without being washed, but for local or nearby markets it is often washed and drained before packing. Although washing is often necessary in some eastern districts to remove soil splashed on the leaves by rain, it is unnecessary in the irrigated districts of the West, where the rainfall is very low.

In some of the Eastern States it was formerly a general practice to pack head lettuce dry in the field and ship it without icing the containers. Many of the more important eastern districts are now following the method used throughout the West—hauling the untrimmed heads to a central packing shed in dumpcarts, trailers, or lug boxes, where the heads are trimmed, graded, and packed in paper-lined crates with some ice in the container. This method assures its arrival in the city markets in better condition than is possible with field packing. Lettuce packed in the field cannot be graded as carefully as that packed in a central packing house, and it is difficult to prepare attractive packages under field conditions.

The United States Department of Agriculture has formulated specifications for standard grades for head lettuce, which are being used more extensively each year. Copies of these may be obtained from the Production and Marketing Administration, United States Department of Agriculture, Washington 25, D. C.

Lettuce was formerly marketed in packages of numerous shapes and sizes, but now only a few standard containers are in use. Almost all western lettuce is marketed in the large, standard western crate, which is approximately 13½ by 17½ by 21½ inches. Crates having minor differences in these measurements are used in different localities. In the West, a 9- or 9½- by 13- by 21⅝-inch crate—the so-called half, or pony, crate—is also common.

These two containers, or crates of similar dimensions, are now being used very generally throughout the East. The hamper, formerly common in the East, is now used only to a limited extent, as in Florida.

Before being packed, the crates are usually lined with heavy paper so placed as to lap over the top and bottom, completely enclosing the contents after the crate is filled. The heads are packed in layers with the stems upward. The number of heads per crate varies according to the size of head, the large western crate containing 36, 42, 48, 54, or 60 heads each. The 4-dozen size is

considered the most desirable. Usually 24 heads are packed in the half crate, but the number varies, depending on the size of the heads. From 20 to 30 pounds of crushed ice is placed between the layers and on the top layer in the large crates. Enough lettuce and ice should be put in the crates to cause about an inch bulge both top and bottom when the lid is brought down for nailing in the press.

Lettuce is a perishable crop and requires extreme care in handling. Cutting, loading, trimming, and packing should be done with care to avoid destroying the wrapper leaves and bruising the heads. The cut heads should be protected from the sun and wind as quickly as possible by hauling them to the packing shed. The more promptly the cut heads are trimmed, packed, iced, and placed in refrigerated cars or trucks the better will be the chance for the product to reach the city market and the consumer in good condition.

Many large growers and shippers market their lettuce under their own brand names, in which case a paper label bearing the brand name is pasted on one end of the crate prior to packing. Smaller growers usually have their product identified by a grower's number stamped on the crates. The number of heads per crate or some other indication of size or quality is also stamped on each crate.

The packed crates should be lidded and placed in a precooled car or truck as soon as possible. The loaded cars are provided with ice to maintain a low temperature during transit. The amount of ice used and its distribution in the car depend on the season and the distance to market. It takes 10 to 13 days for cars from the Pacific coast to reach the large eastern markets. In periods of high temperature top or body icing is used in addition to bunker icing. During the cooler months bunker icing is often omitted and only a heavy top icing is used.

The lettuce crop from the South Atlantic States is moved to northern markets in refrigerator cars and trucks. The use of trucks in shipments from the South has increased in the past few years. The lettuce growers of the Eastern States have the advantage of a short haul to the large consuming markets, with lower freight and refrigeration costs and the additional advantage of being better able to take advantage of fluctuating market demand and prices.

OTHER TYPES OF LETTUCE

Cos lettuce is prepared for market in much the same manner as head lettuce. Most of it is packed in the half crate with or without ice.

Leaf lettuce is grown in a limited way as an outdoor crop for local market. The varieties Early Curled Simpson and Grand Rapids are used mainly for this purpose. Grand Rapids is grown extensively in greenhouses during the fall and winter, especially in Michigan, Indiana, Ohio, western Pennsylvania, and western New York. Although it is sometimes shipped to the large markets in solid carlots, most of the leaf lettuce is shipped in smaller lots by either express or motortruck. Leaf lettuce is usually marketed in 14- and 22-quart, square-cornered, splint baskets holding from

6 to 10 pounds, in 1-bushel standard stave baskets holding 15 pounds, and in standard 3-bushel barrels. It is sold mainly by the pound. Some leaf lettuce is grown in coldframes during early spring and sold locally to stores and consumers. Standard containers are not generally used for this lettuce, but any crates, baskets, or boxes that may be available are used for delivery to the stores.

Stem lettuce has been grown mostly in home gardens for family use, but after leaves have been removed the stems may be marketed in bunches like asparagus and broccoli.

ECONOMIC ASPECTS OF LETTUCE PRODUCTION

From 1929 to 1938, inclusive, the annual commercial crop of head lettuce averaged about 19,000,000 crates. The lowest production for this period was 17,380,000 crates in 1933 and the highest 21,104,000 crates in 1936. Since 1938 the total annual production has been higher, averaging 27,600,000 crates for the succeeding 10-year period, 1939–48, inclusive. Since 1938 the lowest annual production was 22,095,000 crates in 1940. An all-time high was reached in 1947, when the commercial crop amounted to 34,170,000 crates.

The average annual acreage for 1929 to 1938 was 155,990, and for 1939 to 1948 it was 170,700. Much of the difference in commercial lettuce production during the two 10-year periods was due to the larger per acre yields in the later decade. The average per acre yield for the 1929–38 period was 125 crates; in the 1939–48 period it rose to 162 crates. Variations in climatic conditions have a marked influence on yields, but such variations are likely to be abrupt. The consistently high per acre yields for the 1939–48 period as compared with the preceding 10 years indicates that there was some basic reason for the greater yields. Since cultural practices have changed very little during these years, it appears that the increase in yields reflects the superiority of the varieties that have been introduced in recent years. The new varieties are more certain than most of the older ones to produce marketable heads free of disease. Some of them have a greater range of adaptability and can be grown in areas where the older varieties failed to make a crop. This greater range of adaptation has resulted in an expansion of the industry in certain localities.

With the ever-increasing labor and other production costs acre yields are becoming more and more important. Further advances in the economy of production through higher per acre yields can be expected as the result of breeding for varieties that are better adapted and more resistant to disease being done by the United States Department of Agriculture and the State experimental stations.

There is still much opportunity for increases in per acre yields. The 162-crate average for the period 1939–48 means that only about one-third of the plants that would represent a full stand are harvested. In other words, 162 crates per acre represent only about one-third of the plants that can be grown on an acre when the standard row width and spacing distances are used. Failure of many plants to form a commercially marketable head has been

an important reason for low yields. This is being overcome to a marked extent by the introduction of new varieties. Tipburn, aster yellows, mosaic, sclerotiniose, and rhizoctonia bottom rot cause heavy losses and reduction in yields. Much progress has been made in the control of tipburn through breeding for resistance. Some of the new varieties, Great Lakes, Progress, and Imperial 456, are much more resistant to tipburn than the old New York and Imperial strains. The losses from mosaic and aster yellows will, no doubt, be reduced as better control of the insects that spread these virus diseases is obtained through the use of newly developed insecticides.

Improved methods of handling, transportation, and storage have reduced the loss of lettuce between the point of production and the consumer.

Expansion of the production of lettuce resulting from its wider use has about reached its maximum under present conditions. Further increase in consumption of lettuce can be expected, but as the result of an increase in population rather than of greater per capita consumption.

Introduction of some new strains of crisphead lettuce, the variety Great Lakes in particular, has resulted in a shift of the important production centers. Further shifting of acreage in the important production areas may be expected as other disease-resistant and better adapted strains are introduced and as other crops compete successfully with lettuce. There is no reason to expect any abrupt increase in the consumption of lettuce that would justify an expansion in production.

The cost of production varies with the locality, but under nearly all conditions lettuce is an expensive crop to produce. It requires good land, large quantities of fertilizer, and much expensive hand labor. Profitable yields can be obtained only on the best of land, favorably located and properly tilled. High-quality production and rigid standardization are necessary to maintain and develop the demand for lettuce. The marketing of low-grade lettuce at certain times has done much to lower prices and reduce demand.

DISEASES OF LETTUCE

The most important diseases of lettuce are damping-off, tipburn, downy mildew, big vein, mosaic, drop or sclerotiniose, bottom rot, and aster yellows. Losses, generally of minor local importance, are caused by wilt, anthracnose, and other leaf spots. Many lettuce diseases can be controlled only by rotation, sanitation, or the use of resistant varieties.

In using poisonous chemicals to control diseases for which they are effective, care should be taken, as recommended for insecticides (p. 40).

DAMPING-OFF

The term "damping-off" is used to indicate either the decay of the seed or seedlings in the soil or the collapse and death of small seedlings as a result of the destruction of the tissues of the stem

near the soil surface. This condition may be caused by any one of a number of fungi common in the soil. The disease may become evident as soon as the plants have emerged above ground and may continue to cause destruction until the stems have formed woody tissues. Occasionally damping-off may cause some loss of plants in the field, but it is primarily a disease in the seedbeds. It often appears in small localized spots, but may spread rapidly and destroy an entire bed if the ventilation is poor and the bed is kept too damp. Avoiding excessive moisture and providing good ventilation will help to reduce the chances for the development of damping-off. Much can be done also by using a light sandy soil that dries out rapidly, especially for the surface covering of the beds.

Where damping-off has caused serious loss of plants in the seedbeds it is advisable to change the soil or to move the beds to a new place. If it is necessary to use soil where damping-off organisms are known to be present, the soil should be sterilized with chloropicrin or formaldehyde.

Chloropicrin (tear gas) has been found to give good results as a soil disinfectant. The chemical as sold under a trade name comes in gas cylinders under pressure and is applied by means of devices designed by the manufacturers for injecting it into the soil. Unless one has had experience in the use of chloropicrin, a county agent or someone experienced in handling it should be consulted before undertaking to use it.

Care should be taken that none of the chemical comes in contact with the clothing, skin, and especially the eyes, as it is irritating. It is very injurious to plants.

In using chloropicrin it is important that the soil be loose, friable, and fairly moist and that the temperature be between 60° and 85° F. The chemical is applied by injecting about 2 cubic centimeters of the liquid at a depth of 5 or 6 inches at intervals of about 10 inches. After the application the holes should be filled immediately and the soil pressed down and wet to a depth of about 1 inch to form a water seal, thus preventing the escape of the gas. Where possible it is advisable to cover the soil with paper or other suitable cover. The seal should be maintained for about 3 days. The treated soil should not be used as a seedbed until the gas has escaped, as it is very injurious to plants. The time required depends on the temperature and moisture content of the soil, under average soil conditions about 1 week. Working the soil to a depth of several inches hastens the escape of the gas.

Formaldehyde is frequently employed as a soil disinfectant. The commercial product generally available is a 40-percent solution sold as formalin. As a soil disinfectant, formalin should be diluted in the proportion of 1 gallon to 30 gallons of water and this applied at the rate of 1 quart per square foot of soil. The soil should be loose, friable, and fairly moist. After applying the solution, the soil should be given a thorough wetting and covered for about 2 days. The cover should then be removed and the soil permitted to dry. This may require 2 weeks or longer, depending on the temperature. It is important that most of the moisture be removed from the soil before it is used as a seedbed. Water tends to hold

the formaldehyde in the soil, and serious injury to germinating seed may result if the soil is not sufficiently dried out after the treatment.

The use of chemical dusts is effective in preventing the decay of the seed and the killing of young seedlings before they emerge from the soil. The following materials have been found to give protection against damping-off when used at the rates indicated: Red copper oxide (Cuprocide) or zinc oxide, at the rate of 2 percent by weight of seed; or organic mercury dust (Semesan), at the rate of a level teaspoonful per pound or one-half ounce to 15 pounds of seed. The seed with the proper amount of the protectant should be placed in a tightly closed container and shaken 3 or 4 minutes, or until each seed is thoroughly coated. Any excess dust may be screened off and saved for other treatments. The seed is then ready to plant.

TIPBURN

Tipburn is the most widespread of all diseases common to lettuce, occurring in every lettuce-growing district of the country under both field and greenhouse conditions. It is a nonparasitic malady most prevalent during periods of high temperature. Plants in a succulent condition resulting from rapid growth are more susceptible to tipburn than those less succulent. As far as they are within the grower's control, conditions that stimulate rapid, watery growth should be avoided, especially during the late stages. A lettuce crop grown with a uniform moisture supply at a fairly high level is more likely to escape injury by tipburn than one in which the growth rate of the plants is irregular because of fluctuating moisture supply. Excessive fertilization, especially with readily available forms of nitrogen, should be avoided where the crop is to mature during warm weather.

Tipburn is characterized by the breaking down of the tissues of the actively growing leaves at their margins. The first evidence of the breakdown is often the development of small brown or black spots in the tissues near the larger veins. As the breakdown advances the marginal area dies. The dying seldom extends more than a half inch from the edge of the leaf, but in severe cases a discoloration of the large veins may extend for some distance.

The greatest loss from tipburn results from secondary decay caused by certain fungi and bacteria that infect the dead tipburned areas.

As tipburn results from conditions largely beyond the grower's control, the only promising method of combating the disease is the development of varieties better able to withstand the environmental conditions that cause it. The United States Department of Agriculture and the State experiment stations have made progress in breeding varieties resistant to tipburn.

DOWNY MILDEW

Downy mildew is widespread on lettuce but is probably more common under field conditions in some of the Western States than in most of the lettuce-growing districts of the East. It some-

times causes trouble where lettuce is grown under glass. The disease, caused by the fungus *Bremia lactucae* Regel, first appears as light-green or yellowish areas on the upper surface of the leaves, then the downy white growth of the causal organism appears on the under side of the leaf, opposite the discolored spots. As the disease progresses the affected areas turn brown. Downy mildew is most likely to develop in damp, foggy, moderately warm weather.

Downy mildew also attacks wild lettuce and perhaps some other closely related species. Wild lettuce near the lettuce field or greenhouse should be eradicated as a precautionary measure. Although not generally practical under field conditions, the application of a 2–4–50 bordeaux mixture (or a 20–80 copper-lime dust) may be used to check the disease, particularly in plant beds and greenhouses.

BIG VEIN

Big vein is a relatively new disease of lettuce, having been first reported in California in 1934. It is now known to be widespread in both eastern and western lettuce fields. Observable symptoms of big vein do not become noticeable generally until the plants have developed several true leaves. It usually requires 4 to 6 weeks from the time seed is planted or plants are set in diseased soil for symptoms to show in the leaves of the plant.

The observable symptoms of big vein in the leaves of lettuce consist largely of the disappearance of chlorophyll from the leaf tissues adjacent to the large veins and in extreme cases a swelling of the larger veins in the petioles and midribs (fig. 10). Badly affected leaves become more brittle and more easily broken than healthy ones. Big vein does not cause complete destruction of the plant, but it interferes with normal growth and may have an adverse effect on heading.

Big vein is sometimes confused with lettuce mosaic. The leaf symptoms are quite different, as can be seen by comparing figures

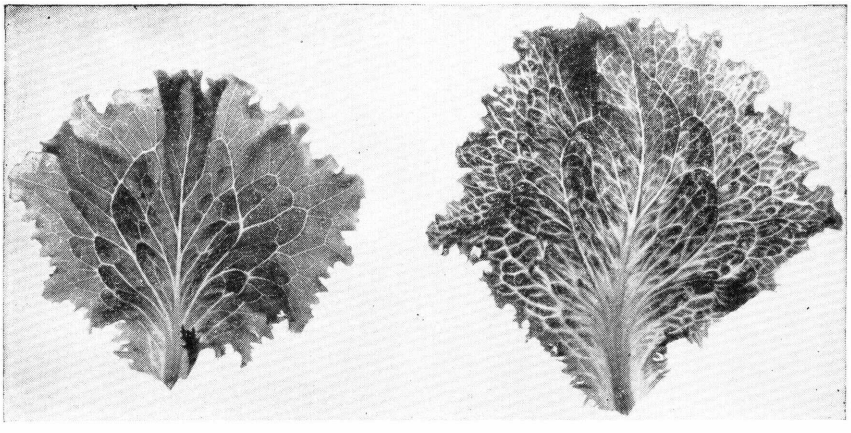

FIGURE 10.—Big vein disease of lettuce: Normal, healthy leaf (left); leaf of same variety showing typical big vein (right).

10 and 11. The influence of temperature on the activity of the two viruses is different. Big vein symptoms are most evident at relatively low temperatures and may not appear at all or may be nearly masked out at higher temperatures. The higher temperatures favor lettuce mosaic, and it is most destructive when temperatures are high. Mosaic gives a definite mottled appearance, due to different densities of green in various parts of the leaf, and there is no distortion or clearing of the area adjacent to the veins, which is characteristic of big vein.

Soil once infected with big vein may remain capable of causing the disease in lettuce for a number of years. There is at present no known practical control under field conditions. The virus causing the disease may be killed in soil by steam sterilization and by disinfection with chemicals such as chloropicrin, formaldehyde, and perhaps others, but the cost of all of these is too high for general use. Although the virus may remain in the soil and cause infection for many years, there is evidence that the loss from big vein can be much reduced by a rotation practice in which lettuce is not planted on the same land more often than once in 3 or 4 years.

Big vein cannot be spread from plant to plant by mechanical means and there is no known insect vector, although root aphids are suspected of being able to carry the virus.

MOSAIC

The virus disease lettuce mosaic is widespread. It is present in all the important lettuce-growing districts of the United States and has been reported in Great Britain, continental Europe, Palestine, Egypt, and Australia. Early symptoms (which may appear on very small plants where the disease is seed-borne) are a mottled appearance of the leaves resulting from different densities of green pigment (fig. 11) and a deformed condition of the affected leaves. As the disease advances the plant may show a yellowish color and marked stunting. The effects of the disease are more marked in warm weather, when the margins of the affected leaves may turn brown and the leaves die. In extreme cases, the entire plant may die.

The widespread occurrence of lettuce mosaic is no doubt due largely to its being seed-borne. The extent of seed-borne mosaic does not usually exceed 2 percent. That is, not more than about 2 percent of the plants grown from seed produced by a mosaic-infected plant will show mosaic symptoms in the seedling stage.

The disease apparently cannot be transmitted by ordinary methods of inoculation. It is spread from diseased to healthy plants by various species of plant aphids that first feed on mosaic-infected plants and then on healthy ones. There may be wild-plant hosts carrying the mosaic virus that serve as a source of infection of lettuce fields. However, the chief source of field infection is no doubt the seedlings from seeds carrying the virus. Unless removed as soon as they can be recognized, they may serve to infect an entire field in a short time after aphids make their appearance.

Much of the commercial lettuce seed produced in this country carries some seed-borne mosaic. The seriousness of the loss re-

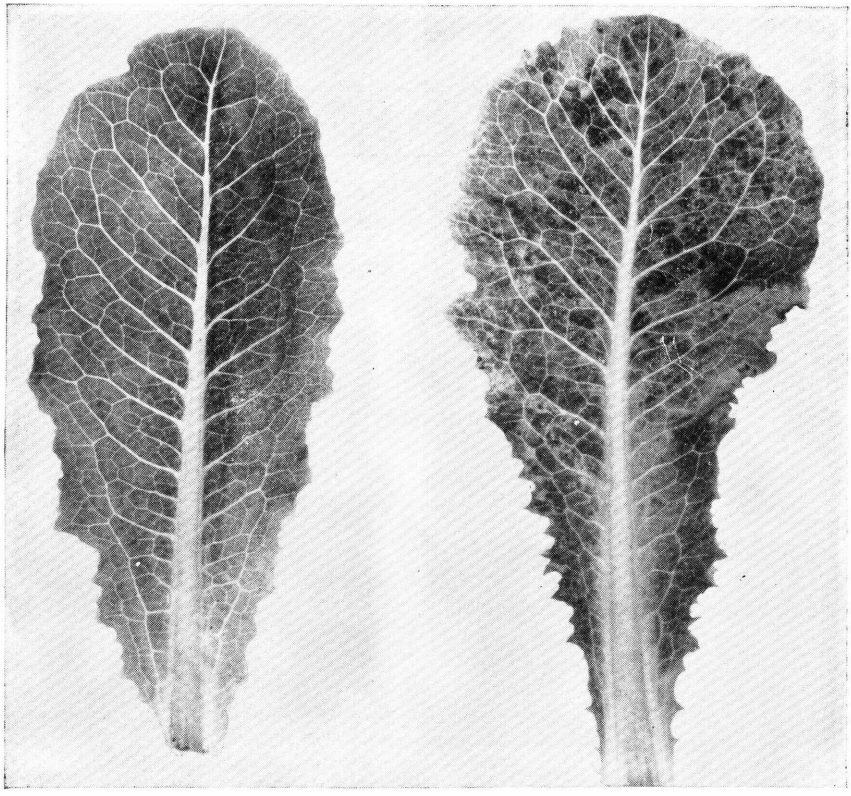

FIGURE 11.—Mosaic disease of lettuce: Normal, healthy leaf (left); leaf showing typical mottling of mosaic (right).

sulting from mosaic carried into the field on seed is much greater than is generally recognized.

The most effective control of lettuce mosaic would be the elimination of the disease from the seed fields, thereby preventing field infection through plants carrying seed-borne virus.

Much could be done to reduce losses from mosaic by removing the plants carrying seed-borne virus as soon as they can be recognized and before they have been attacked by aphids. With a little study of the symptoms of mosaic as it affects the seedlings, one can soon learn to recognize most of them.

As the virus is spread, so far as known, entirely by insect vectors, control of these insects would greatly reduce the extent of field infection. However, complete elimination of aphids through a dusting or spraying program may be very difficult where the aphid population is large.

Lettuce mosaic is often confused with big vein disease (p. 34).

DROP, OR SCLEROTINIOSE

Drop of lettuce is caused by certain closely related species of fungi (*Sclerotinia sclerotiorum* (Lib.) DBy., and *S. minor* Jagger). Very young plants affected by the disease wilt and die rapidly.

Symptoms of the disease in older plants vary, depending upon its rate of development. In some cases the rate of advance is very rapid and the entire plant may wilt down into a slimy mass; if the rate is slower the symptoms may first be recognized by the wilting of the outer leaves. Examination of the plant at the soil surface reveals water-soaked spots on the stem near the soil line and similar ones on the petioles and lower parts of the outer leaves. As the disease progresses, the leaves, starting with the outer ones and continuing inward, droop and finally fall to the ground. It is the appearance of the plant in these late stages that has given the name drop to this disease (fig. 12). Sometimes the diseased stems show a pink, reddish, or brown discoloration. If

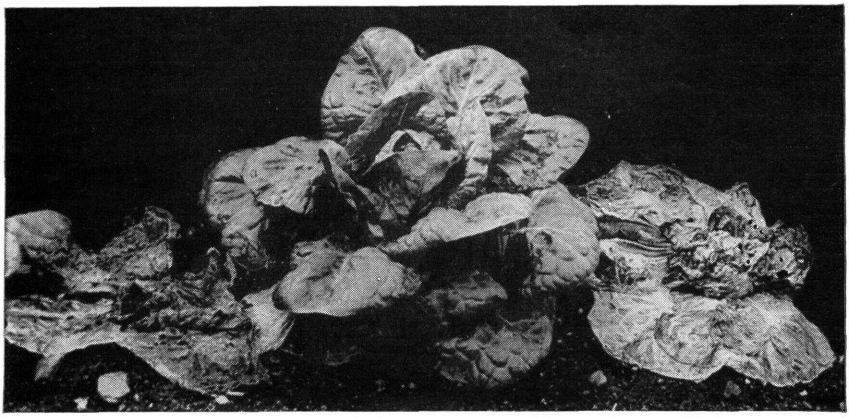

FIGURE 12.—Lettuce plants destroyed by drop.

soil moisture becomes low and is accompanied by low humidity after infection the advance of the disease may be retarded or checked altogether after only a few leaves and the outer tissues of the stem have become infected. In such cases the plant may survive and continue to grow at a very much reduced rate for some time before succumbing.

The organisms causing drop are widespread throughout the United States and may attack a great many other plants besides lettuce. They are capable of causing loss in transit, in storage, and on the market, as well as in the field. They produce reproductive bodies that may live for long periods on diseased plant tissues in the soil.

In greenhouses it is possible to control drop by thorough sterilization of the soil by steam or by disinfection with chloropicrin or formaldehyde (p. 32). If only a few plants are affected, spread of the disease may be at least partially controlled by removing them carefully. In the field, soil sterilization is impractical but sanitary measures afford some control.

As the disease develops most rapidly under cool, moist conditions, the use of well-drained soil that dries out rapidly on the surface will reduce the chances for infection. The plants should not be crowded; the fungus may spread from plant to plant. Weeds

should be held down, as some of them may be hosts and weed growth may reduce ventilation and prevent surface drying.

No lettuce varieties are known to be immune or resistant to drop.

BOTTOM ROT

Although not generally widespread, bottom rot is highly destructive to lettuce in some localities nearly every season. It is caused by *Rhizoctonia solani* Kuehn, one of the organisms that commonly cause damping-off. The plants may be attacked at nearly all stages of growth, and the disease may be present throughout the growing season.

Bottom rot is at first characterized by rust-colored sunken lesions on the petioles and midribs and a slimy rot on the blades of the bottom leaves of the plant that touch the soil. As the disease advances, it spreads from the lower leaves upward until the entire head becomes a slimy mass.

The bottom rot organism enters the plant through the lower leaves that are in contact with the soil. Varieties that have an upright habit of growth and little contact with the soil, the cos varieties in particular, are less subject to bottom rot than those, like Big Boston, in which the lower leaves spread out in contact with the soil.

The causal organism requires a moderately high temperature and abundant moisture for development. Frequently a severe epidemic of bottom rot develops during a period of warm, damp weather and then disappears if a period of dry weather follows.

Rotation of lettuce with other crops, such as sweet corn and onions, which are not attacked by the causal organism, is the only practical means of control, field sterilization being impractical. Only well-drained land should be planted to Big Boston and other low-growing varieties where bottom rot is present.

ASTER YELLOWS

Within the last few years, aster yellows has become a very serious disease of lettuce in some of the important lettuce-growing districts, particularly in the Northeastern States. The disease is caused by a virus that produces a similar disease in many other species of plants. The name aster yellows was given to the disease because of its having first been found and identified on asters.

The virus causing the disease is spread from plant to plant by insects feeding upon them. So far as is known, only one species of the leafhopper is capable of spreading the virus. The insects first become carriers of the virus by feeding on diseased plants. Lettuce fields are generally infected by leafhoppers that have overwintered on diseased wild plants.

The disease is characterized by yellowing of the leaves and flower parts (fig. 13). In young plants the central leaves and those actively growing are the first to show the characteristic yellowing. In older plants one side may show yellowing while the rest of the plant is still green. In plants that have developed a seed stem before being inoculated, some of the laterals may show

FIGURE 13.—Seed stems of a plant affected with aster yellows (left) and a normal plant (right).

the disease while others remain healthy. If the terminal growing point of the stem is inoculated, the disease spreads through the entire plant and all the flowers may show symptoms of the disease. In diseased flowers the petals become thickened and abnormally enlarged and take on a greenish color instead of the normal yellow.

There is no practical control for aster yellows other than destroying the insect carriers.

INSECT ENEMIES OF LETTUCE [1]

Lettuce may be attacked by several kinds of insects, the principal ones being cutworms, the cabbage looper, the six-spotted leafhopper, wireworms, and aphids. Attacks by these insects, with the possible exception of cutworms, are not general. Cutworms may damage lettuce in almost every area where the crop is grown, whereas injury by any one of the other insects is generally localized.

CAUTION: The insecticides suggested for use on lettuce are poisonous. Handle them with care. Store them in a dry place and where children or animals will not have access to them. Do not apply DDT or cryolite on any portion of the plant that is to be marketed or used as food. Rotenone and pyrethrum insecticides at the dilutions and dosages recommended do not leave on the plants residues that are harmful to man or warm-blooded animals.

CUTWORMS

Cutworms are particularly destructive to lettuce seedlings and may cause considerable damage as the seedlings appear above ground, or when plants are set in the field. Some species of cutworms overwinter in the soil, and as soon as the weather becomes favorable in the spring they are ready to attack the early planted crop. Late-season crops of lettuce may be damaged by cutworms that pass the winter in the egg stage. Cutworms feed for the most part at night, and spend the day inactive just below the surface of the soil. They cut into the stem of the plant a short distance above the ground, and when the crop is reaching maturity they may feed on the leaves and burrow into the developing heads.

On the young crop cutworms may be controlled by timely applications of a poisoned bait containing 1 pound of sodium fluosilicate or paris green to 25 pounds of bran, moistened with water. It is important that each particle of bran carry a little poison and be moist. Therefore, the dry ingredients should be thoroughly mixed first, and the water added slowly, with continued mixing, so that the poison will not be washed from the bran flakes. The bait should be dry enough so that it crumbles readily on being squeezed in the hand.

It is good practice to apply the bait before the lettuce plants come up or the crop is set in the field, especially if the land was

[1] This section prepared by W. H. White, formerly in charge, Division of Truck Crop and Garden Insect Investigations, Bureau of Entomology and Plant Quarantine, Agricultural Research Administration.

in sod the previous year. Grasslands are likely to have larger populations of cutworms than lands that have been under cultivation. Bait applied before the crop is planted should be broadcast late in the evening at the rate of 10 to 15 pounds per acre. Bait applied after the crop has appeared above ground should be distributed along the rows, with care to keep as much of it from the plants as possible, as the sodium fluosilicate may cause some injury. An even, light distribution is as effective as a heavy, uneven distribution.

Cutworms may also be controlled by dusting the soil surface and young plants with 5-percent DDT dust at 40 pounds per acre or by spraying with 4 pounds of 50-percent DDT wettable powder in 100 gallons of water per acre. It is helpful to work the DDT into the top inch of soil lightly with a rake or harrow.

CABBAGE LOOPER

The cabbage looper[2] feeds on lettuce and, unless controlled, may cause serious loss to the crop in some seasons, particularly in Florida, California, and Arizona. For control of the loopers on the seedling crop—that is, up to 35 or 40 days before harvest—a 5-percent DDT or a 50-percent cryolite dust is most satisfactory. During later stages of growth either a 0.75-percent rotenone dust or a 0.2-percent pyrethrin dust should be used. The dusts should be applied at 20 to 25 pounds per acre. Sprays are also effective when applied at the same rate of active ingredient per acre.

If possible the loopers should be controlled in their early stages of development, as it is difficult to control them in the later stages with rotenone and pyrethrins.

If the seedling crop is infested before it is thinned, the plants left standing after this operation are liable to severe injury, as loopers on the plants that are pulled will move on to the plants left standing. Where early infestations are likely to occur, it is good practice to treat the lettuce seedlings before they are thinned.

SIX-SPOTTED LEAFHOPPER

The six-spotted leafhopper[3] is a tiny, green, wedge-shaped insect that is likely to be undetected until after lettuce is injured. The leafhopper damages lettuce indirectly by spreading aster yellows. As it is difficult to control the insect, control of the disease is also difficult. The insecticide most effective against the insect is DDT, which is applied as a dust or spray to the young plants as for the cabbage looper. Pyrethrum is not very effective, but is safe and useful against this leafhopper after marketable leaves appear on the lettuce plants. Pyrethrum is applied as for the cabbage looper.

APHIDS AND OTHER PESTS

Aphids, or plant lice, occasionally become troublesome on lettuce. A useful remedy is nicotine, which can be applied either in the

[2] *Trichoplusia ni* (Hbn.).
[3] *Macrosteles divisus* (Uhl.).

form of a spray or as a dust. The dust should contain 3 percent of nicotine. Nicotine dusts are not effective at low temperatures, and where possible the treatments should be made when the air temperature is above 70° F. and when the foliage is dry. It is important that the dust reach the innermost parts of the plants, as the nicotine kills the aphids only when it comes in contact with the insects.

Whether used for aphids or for other insects, dusts are more effective if applied when there is little wind. A cloth trailer attached to the rear and above the dust boom helps to hold the dust over the plants for a short time after it is discharged, especially when the wind velocity is above 5 miles an hour.

When armyworms and the corn earworm[4] attack lettuce in its early stages of growth, they may be controlled with DDT or cryolite, as applied for the cabbage looper. Rotenone and pyrethrum, however, are ineffective against these pests.

Wireworms in irrigated lands of the West may be controlled by dusting or spraying the soil with 10 pounds of DDT per acre and working it into the soil to a depth of 6 or 8 inches. Several months are required for this treatment to control wireworms, but the DDT remains effective in the soil for several years. Quick control of wireworms may be obtained by fumigating the soil with ethylene dibromide. Lettuce growers wishing further information on wireworm control should consult their State entomologist or extension service, or the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, Washington 25, D. C.

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[4] *Heliothis armigera* (Hbn.).

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